REMARKS

Claims 1-5 are pending in this application. Claims 3 and 4 have been withdrawn from examination as being directed to a non-elected species.

Drawing Objections

The drawings stand objected to under 37 C.F.R. § 1.83(a) for failing to show every feature of the invention specified in the claims. Reconsideration of these objections is respectfully requested.

The Examiner stated that the amendments to claim 1 made in the July 9, 2003 Amendment reciting that the dividing head is for carrying out angular division of a circular table and that a worm wheel is assembled into a worm wheel shaft attached to the circular table is not shown in the drawings. The Applicant respectfully disagrees.

In the first full paragraph on page 6, the specification states that to each worm wheel shaft 14, a circular table 24 is attached. The circular table 24 is further discussed throughout the specification. Additionally, reference numeral 12 shows the worm wheel, reference numeral 14 shows the worm wheel shaft, and reference numeral 24 shows the circular table in the drawings. Therefore, the Applicant believes that the drawings sufficiently show the claimed feature of "a worm wheel assembled into a worm wheel shaft attached to a circular table". Furthermore, the drawings (namely Figs. 1-4) fully show the mechanical structure of the dividing head 10 for rotating the circular table 24. Therefore, the Applicant believes that the drawings sufficiently show "the angular division of a circular table".

Specification Objections

The specification stands objected to because the Examiner feels that the Amendment filed on July 9, 2003 introduces new matter into the disclosure. Reconsideration of these objections is respectfully requested.

The Examiner stated that the addition of the table being intended to be angularly divided by the dividing head and the worm wheel being assembled into a worm wheel shaft attached to the circular table added new matter. The Applicant respectfully disagrees.

In the first and last paragraphs on page 6, the specification clearly describes the angular division of a circular table and the relationship between the worm wheel, worm wheel shaft, and the circular table. The phrase "an angular division is carried out" in the last paragraph on page 6 may also be read as "an angular dividing is carried out".

Additionally, it would be readily understood by any person skilled in the art that a dividing head is an apparatus that performs angular dividing of a circular table. This is a common term of art as evidenced by the Chambers Dictionary of Science and Technology definitions for "dividing head" and "indexing head" attached as Appendix A and the article entitled "Using a Dividing Head and Making One for Your Lathe" attached as Appendix B. In any event, the use of a dividing head is clearly described in the last paragraph on page 6 of the specification.

Therefore, the Applicant believes that the specification in its original form supports such language added by the July 9, 2003 Amendment and that the Amendment simply provided minor clarifications. Thus, the Applicant submits that no new matter was added by the July 9, 2003 Amendment.

35 U.S.C. § 112 Rejections

Non-enablement

Claims 1, 2, and 5 stand rejected under 35 U.S.C. § 112, first paragraph, for indefiniteness by containing subject matter that was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor had possession of the claimed invention. Reconsideration of these rejections is respectfully requested.

The Examiner stated that the language that was amended into the claims, namely that the dividing head using a multiple type worm is for carrying out angular division of the circular table and that a worm wheel assembled into a worm wheel shaft attached to a circular table, was not set forth or even implied by the original specification. The Applicant respectfully disagrees.

The Applicant submits that, given the originally filed specification, one skilled in the art would reasonably understand what a dividing head is, as discussed above in relation to the specification objections and supported by the evidence in Appendices A and B.

Therefore, the Applicant believes that the claims, as they currently stand, are fully enabled by the originally filed specification.

In order to comply with the written description requirement of 35 U.S.C. § 112, first paragraph, the claims need not include exactly the same terms as used to describe the claimed subject matter in the specification. All Dental Produx, LLC and DMG Dental-Material Gesellschaft MBH v. Advantage Dental Products, Inc., 309 F.3d 774, 779 (Fed. Cir. 2002) (citing Eiselstein v. Frank, 52 F.3d 1035,1038 (Fed. Cir. 1995) citing Vas-Cath Inc. v. Mahurkar, 935 F.2d 1555, 1562 (Fed. Cir. 1991) and In re Wertheim, 541 F.2d 257 (CCPA 1976)). The specification needs simply to "indicate to persons skilled in the art that as of the [filing] date the applicant had invented what is now claimed". Id. If the "language is not a model of clarity", but is "fairly simple", "intelligible", and "capable of being understood in the context of the patent specification", then, it is "reasonably clear what the invention is and that the patent specification conveys that meaning". Id.

The instant specification is indeed simple, intelligible, and capable of being understood by one skilled in the art. Therefore, the Applicants submit that the claims are enabled by the specification.

Indefiniteness

Claims 1, 2, and 5 stand rejected under 35 U.S.C. § 112, second paragraph, for indefiniteness. Reconsideration of these rejections is respectfully requested.

The Examiner stated that it is unclear what the structural relationships are between the worm wheel, the worm wheel shaft, and the circular table, and that it is unclear what angular division is with respect to the circular table. The Applicant believes that the above arguments with regard to the specification objections and the non-enablement rejections address these rejections and that the claims, as they currently stand, are not indefinite.

35 U.S.C. § 103 Rejections

Claims 1, 2, and 5 stand rejected under 35 U.S.C. § 103(a) for obviousness based upon U.S. Patent 4,615,230 to Guichard in view of U.S. Patent 4,093,052 to Falk. In

view of the following remarks, the Applicant respectfully requests reconsideration of these rejections.

The Examiner is attempting to rely on the Guichard patent for disclosing a dividing head for angular division of a circular table 217. However, the Guichard patent is directed to a gear transmission, not a dividing head, and, therefore, does not relate to a multiple lead type dividing head. Reference numeral 217 is an output gear-wheel for transmitting rotation of a worm wheel (214a, 214b, etc.), not a circular table of a dividing head. It is clear that output gear-wheel 217 is not attached to a shaft into which worm wheels 4, 6, 214, 216, etc. are assembled. Therefore, the Guichard patent does not, and cannot, render the present claims obvious.

The Falk patent is directed to one embodiment of an assembler used in the present invention. However, the Falk patent is not directed to a dividing head for angularly dividing a circular table. Therefore, the Falk patent does not cure the deficiencies of the Guichard patent.

For the foregoing reasons, the Applicant believes that the subject matter of independent claim 1 is not rendered obvious by the Guichard patent in view of the Falk patent. Reconsideration of the rejection of claim 1 is respectfully requested.

Claims 2-5 depend from, and add further limitations to, independent claim 1, or a subsequent dependent claim, and are believed to be patentable for the reasons discussed hereinabove in connection with independent claim 1. Reconsideration of the rejections of claims 2 and 5 is respectively requested. Also, in light of allowability of claim 1, the Examiner is requested to reinstate and allow dependent claims 3 and 4.

CONCLUSION

In view of the foregoing, the Applicant believes that claims 1-5 are in condition for allowance. Reconsideration of the Examiner's rejections and allowance of claims 1-5 are respectfully requested.

Respectfully submitted,

WEBB ZIESENHEIM LOGSDON
ORKIN & HANSON, P.C.

By _____

John W. McIlvaine
Registration No. 34,219
Attorney for Applicant
700 Koppers Building
436 Seventh Avenue
Pittsburgh, Pennsylvania 15219-1818
Telephone: 412-471-8815
Facsimile: 412-471-4094
E-mail: webblaw@webblaw.com

This Page Is Inserted by IFW Operations
and is not a part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

As rescanning documents *will not* correct images, please do not report the images to the Image Problems Mailbox.

CHAMBERS

DICTIONARY OF SCIENCE AND TECHNOLOGY

Astronomy

Chemistry

General Editor

Professor Peter M B Walker, CBE, FRSE

Geology

Physics

CHAMBERS

through it. Such a lens will be double concave, plano-concave, or convexo-concave, the concave surface having the smaller radius of curvature.

divergent nozzle (*Eng*) A nozzle whose cross-section increases continuously from entry to exit; used, eg in compound impulse turbines.

divergent sequence, series (*Maths*) Definitions vary. Some writers count anything not convergent as divergent. Others use it as synonymous with *unbounded*, excluding finitely oscillating sequences such as $u_n=(-1)^n$. Still others confine it to sequences tending to $+\infty$ or $-\infty$, excluding infinitely oscillating sequences such as $u_n=n(-1)^n$.

divergent strabismus (*Med*) Squint in which the eyes diverge from each other.

divergent thinking (*Behav*) Thinking which is productive and original, involving the creation of a variety of ideas or solutions which tend to go beyond conventional categories (De Bono). See **convergent thinking**.

diversion cut (*CivEng*) See **bye channel**.

diversity (*Ecol*) An index of the number of species in a defined area, often represented mathematically. *Alpha diversity* is on a local scale, *beta diversity* on a regional scale. See **richness**.

diversity antenna (*Telecomm*) The antenna system of a diversity receiver.

diversity factor (*ElecEng*) The ratio of the arithmetic sum of the individual maximum demands of a number of consumers connected to an electric supply system, to the simultaneous maximum demand of the group.

diversity reception (*Telecomm*) System designed to reduce fading; several antennas, each connected to its own receiver, are spaced several wavelengths apart from one another, the demodulated outputs of the receivers being combined. Alternative systems use antennas orientated for oppositely polarized waves (polarized diversity), or independent transmission channels on neighbouring frequencies (frequency diversity).

diver's paralysis, diver's palsy (*Med*) See **caisson disease**.

diverter (*ElecEng*) A low resistance connected in parallel with the series winding or the compole winding of a dc machine in order to divert some of the current from it, thereby varying the mmf produced by the winding.

diverter relay (*ElecEng*) A relay employed with certain excess-current protective systems; it increases the stability of the protective system by putting resistance in parallel with the tripping relay in the case of a heavy fault.

diverticulitis (*Med*) Inflammation of diverticula in the colon.

diverticulosis (*Med*) The presence of diverticula in the colon.

diverticulum (*Med, Zool*) (1) Saccular dilatation of a cavity or channel of the body. (2) Lateral outgrowth of the lumen of an organ. (3) Pouch-like protrusion of the mucous membrane of the colon through the weakened muscular wall. (4) A pouch-like side branch on the mycelium of some fungi. Pl *diverticula*.

divertor (*NucEng*) Trap used in thermonuclear device to divert magnetic impurity atoms from entering plasma, and fusion products from striking walls of chamber. Also *bundle divertor*.

divided bearing (*Eng*) See **split bearing**.

divided pitch (*Eng*) The axial distance between corresponding points on successive threads of a multiple-threaded screw.

divided touch (*Phys*) The magnetizing of a steel bar by stroking it with the opposite poles of two permanent magnets, these being drawn apart from the centre of the bar to the ends.

divided winding (*ElecEng*) A term proposed for that class of windings (for dc machines) usually called multiple or multiplex, in which there are two or more separate windings on the armature, joined in parallel by the brushes.

dividend (*Maths*) See **division**.

divider (*ElecEng*) Circuit which has an output which is a well defined fraction of a given input; can be constructed using resistors or capacitors. Also *voltage divider, attenuator*.

dividers (*Eng*) Compasses used only for measuring or transferring distances, and not for describing arcs.

dividing box (*ElecEng*) A box for separately bringing out the cores of a multi-core cable. The insulation of the cable is hermetically sealed and the cores may be brought out either as bare or insulated conductors.

dividing engine (*Eng*) An instrument for marking or engraving accurate subdivisions on scales; it consists of a carriage adjusted by a micrometer screw and holding a marking tool.

dividing fillet (*ElecEng*) See **barrier**.

dividing head (*Eng*) See **indexing head**.

dividing network (*Acous*) A frequency-selective network which arranges for the input to be fed into the appropriate loudspeakers, usually two, covering high and low frequencies respectively. Also *loudspeaker dividing network, crossover network*.

diving-bell (*CivEng*) A water-tight working chamber, open at the bottom, which is lowered into water beneath which excavation or other works are to proceed. The interior is supplied with compressed air to maintain the water-level inside at a reasonable height, and thus leave free a space within which people may work.

divinity calf (*Print*) Bindings in dark brown calfskin, with **blind tooling**; used chiefly for theological works.

division (*Bot*) Highest taxonomic rank used in the classification of plants (equivalent to the zoologist's **phylum**), ranking above **class**; the names end in −phyta or, for fungi, −mycota.

division (*Maths*) (1) For numbers, the operation of ascertaining how many times one number, the *divisor*, is contained in a second, the *dividend*. The result is called the *quotient*, and, if the divisor is not contained an integral number of times in the dividend, any number left over is called the *remainder*. Indicated either by the division sign, ÷, or by a stroke or bar, in which case the expression as a whole is called a *fraction* and the dividend and divisor the *numerator* and *denominator* respectively. Fractions less than one are called *common* or *proper* or *vulgar fractions*, and those greater than 1, *improper fractions*. Colloquially, however, a *fraction* is less than 1. (2) For complex numbers, the division of $a + ib$ by $c + id$ is given by

$$\frac{a+ib}{c+id}=\frac{ac+bd}{c^2+d^2}+i\frac{bc-ad}{c^2+d^2}$$

(3) For polynomials and other mathematical entities, the inverse operation to multiplication. When appropriate: nomenclature analogous to that outlined above is used.

division plate (*Eng*) A plate used for positioning the plunger of an indexing head; provided with several concentric rings of holes accurately dividing the circumference into various equal subdivisions.

division ring (*Maths*) A ring which, if zero is removed, is a group under multiplication, ie every non-zero element has an inverse. A commutative division ring is a field.

division wall (*Build*) A wall within a building or serving two houses. Also *party wall*.

divisor (*Maths*) See **division**.

dizygotic twins (*Biol*) Twins produced from two fertilized eggs. They may be the same or different sexes and are genetically equivalent to full sibs. Also *fraternal twins*. Cf **monozygotic twins**.

dl- (*Chem*) Containing equimolecular amounts of the dextrorotatory and the laevorotatory forms of a compound; racemic. Now usually written ±.

D-layer (*Telecomm*) The lowest region or layer of absorbing ionization, 55–95 km above the Earth. It impedes short-wave communications by absorbing some of the incident power, but it enhances long-wave communication.

DLC (*Chem*) Abbrev for **diamond-like carbon**.

d-levels (*Phys*) See **diffuse series**.

D lines (*Phys*) See **[D]**.

DLL (*Comp*) Abbrev for **dynamic link library**.

D log E curve (*ImageTech*) See **characteristic curve**.

indexed sequential access (*Comp*) Process of storing or retrieving data directly, but only after reading an index to locate the address of that item. See **direct access**.

index error (*Surv*) Difference between the horizontal or vertical angular reading of theodolite and the true line of its collimation, with regard to concentric centring of the azimuth and plate circle and accurate engraving of the reading lines.

index fossil (*Geol*) A fossil species which characterizes a particular geological horizon. It tends to be abundant, with a narrow time range and a wide geographical spread.

indexing head (*Eng*) A machine tool attachment for rotating the work through any required angle, so that faces can be machined, holes drilled etc in definite angular relationship.

index mineral (*Geol*) One whose appearance marks a particular grade of metamorphism in progressive regional metamorphism.

index of refraction (*Phys*) See **refractive index**.

index search (*ImageTech*) A means of locating places on videotape by coded signals recorded in the **control track**. Also *VISS* (*video/VHS index search system*).

Indian hemp (*Bot*) See **cannabis**.

Indian ink (*Gen/*) Ink in a solid form made from lamp black mixed with parchment size or fish glue. Rubbed down in water it produces an intensely black permanent ink used for line and wash drawings.

Indian topaz (*Min*) See **citrine**, also a misnomer for yellow corundum.

India paper (*Paper*) A thin, strong, opaque rag paper, made for bibles and other books where many pages are required in a small compass.

india-rubber (*Chem*) See **rubber**.

indicated airspeed (*Aero*) The reading of an airspeed indicator which when corrected for instrument errors, reads low by a factor equal to the square root of the relative air density as the latter falls with altitude. Abbrev *IAS*.

indicated horse power (*Eng*) Of a reciprocating engine, the horse power developed by the pressure-volume changes of the working agent within the cylinder; it exceeds the useful or brake horse power, at the crankshaft, by the power lost in friction and pumping. Abbrev *IHP*.

indicated mean effective pressure (*Eng*) The average pressure exerted by the working fluid in an engine cylinder throughout the cycle, equal to the mean height of the indicator diagram in kN m^{-2} or lb f in^{-2}. Abbrev *IMEP*.

indicated ore (*MinExt*) Proved limits of deposit, in the light of known geology of mine and economic factors.

indicated power (*Eng*) See **indicated horse power**.

indicated thermal efficiency (*Eng*) The ratio between the indicated power output of an engine and the rate of supply of energy in the steam or fuel.

indicating instrument (*Eng*) One in which the immediate value only of the measured quantity is visually indicated.

indication (*Eng*) A sign, on inspection which indicates an imperfection of the material.

indicator (*Bot*) (1) The presence of a species which gives an indication of features of the habitat, or method of land management, by growing well or badly; eg the stinging nettle which indicates a high level of available phosphorus in the soil. (2) Plants which react to a particular pathogen or environmental factor with obvious symptoms and may, therefore, be used to identify that pathogen or factor.

indicator (*Chem*) (1) A substance whose colour varies with the acidity or alkalinity of the solution in which it is dissolved. (2) Any substance used to indicate the completion of a chemical reaction, generally by a change in colour.

indicator (*ElecEng*) See **annunciator**.

indicator (*Eng*) An instrument for obtaining a diagram of the pressure-volume or pressure-time changes in an engine or compressor cylinder during the working cycle.

indicator card (*Eng*) A chart on which the trace of an **indicator** is recorded, producing an **indicator diagram**.

indicator diagram (*Eng*) A graphical representation of the pressure and volume changes undergone by a fluid, while performing a work cycle in the cylinder of an engine or compressor, the area representing, to scale, the work done during the cycle. See **indicated mean effective pressure**, **light-spring diagram**.

indicator gate (*Electronics*) A step or pulse signal applied to a cathode-ray tube to control its sensitivity, in order to highlight a certain part of the display.

indicator range (*Chem*) The range of pH values within which an indicator (1) changes colour.

indicator species analysis (*Ecol*) Multivariate statistical technique to enable classification of vegetation on the basis of the presence or absence of key species.

indicator tube (*Electronics*) Miniature cathode-ray tube in which size or shape of target glow varies with input signal.

indicator vein (*MinExt*) In prospecting, one associated with the lode or vein being traced, thus guiding the search.

Indices of crystal faces (*Cryst*) See **Miller indices**.

indicial admittance (*Telecomm*) Transient current response of a circuit to the application of a **step function** of one volt, using Heaviside operational calculus.

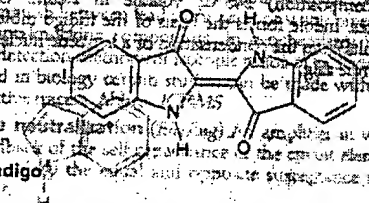
indicial response (*Telecomm*) Output waveform from a system when a step pulse of unit magnitude is applied to the output.

indicolite (*Min*) A blue (either pale or bluish-black) variety of tourmaline. Also *indicolite*.

indigenous (*Zool*) Native, not imported.

indigestion (*Med*) A condition, marked by pain and discomfort, in which the normal digestive functions are impeded. Also *dyspepsia*.

indigo (*Chem*) $C_{16}H_{10}N_2O_2$. A dye occurring in a number of plants, esp in species of *Indigofera*, in the form of a glucoside. It is an indole derivative. Indigo is a very important blue vat dyestuff, and can be synthesized in various ways.



Indigo

indigo copper (*Min*) See **covellite**.

indigolite (*Min*) See **indicolite**.

indirect address (*Comp*) The address specified in the instruction is that of a location which in turn contains the required address.

indirect-arc furnace (*ElecEng*) An electric arc furnace in which the arc is struck between two electrodes mounted above the charge, the latter being heated chiefly by radiation.

indirect cycle (*NucEng*) Nuclear power plant in which the core coolant passes through a heat exchanger in which the secondary circuit of water produces steam for the turbines, as in a pressurized water reactor.

indirect-fired furnace (*Eng*) One in which the combustion chamber is separate from the one in which the charge is heated.

indirect heating (*Eng*) A system of heating by convection, as opposed to *direct heating* by radiation.

indirect immunofluorescence (*Biol*) Technique in which a specific antibody is first bound to its antigen. A fluorochrome visible under **fluorescence microscopy** and conjugated to a second antibody specific to the first is then used to detect the presence of the first antibody and therefore the original antigen.

indirect lighting (*ElecEng*) A system of lighting in which more than 90% of the total light flux from the fittings is emitted in the upper hemisphere.

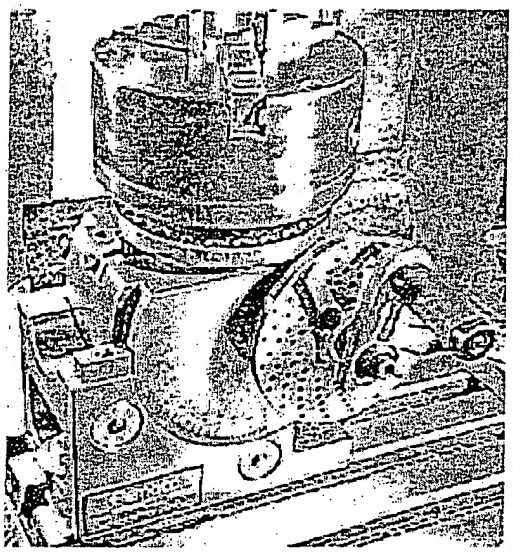
Using a Dividing Head

and Making One for Your Lathe

by Jim Sapp

Using the Standard Dividing Head

A dividing head is a tool that is used to divide a circle into equal divisions. I am not refering to degrees or radians, so don't think in those units. *Think divisions.* Have you ever tried to lay out a circle divided into say, 37 equal parts? It's a snap with a dividing head. Pictured below is an example of a typical unit.



In a nut shell, a dividing head is simply a spindle mounted with a precision worm wheel and provided with a crank attached to the worm shaft. The crank's handle is equipped with a spring loaded plunger that will drop an indexing pin into equally spaced holes in a disk mounted behind the crank. The spindle is provided with the means to mount a chuck or collet attachment for holding a workpiece. It is also provided with a lock for clamping the spindle in position for increased rigidity. These units are usually mounted such that the spindle's axis can be tilted through 90 degrees, to provide an additional axis of adjustment.

Most units are made with a 40:1 reduction in the worm, such that 40 turns of the crank will rotate the spindle through one full turn. The indexing plate (the disk with concentric circles of equally spaced holes behind the crank) provides a handy positive index for positioning the crank at 1/n turns of the crank, where n equals the number of holes in the disk. The plunger can be positioned along the arm of the crank to select which circle of holes you wish the indexing pin to engage. These indexing plates are usually interchangeable to provide a wide variety of choices for n, so that one turn of the spindle can be divided into a great variety of equal parts.

The crank is outfitted with a pair of sector arms which can be adjusted to indicate the correct number of holes for any partial turn of the crank you must make. This eliminates the need to count holes on every subsequent advance of the spindle.

APPENDIX B

Dividing a circle into 40 equal parts is pretty straight forward since the worm wheel has 40 teeth - one full turn of the crank equals one fortieth of a circle at the spindle. To divide a circle into 20 parts: two turns of the crank would equal two 40ths, or one 20th of a circle. One fourth of a crank turn (or 6 holes in a 24 hole index circle) would equal one 160th of a circle at the spindle. Here is the formula:

crank turns = 40 / N

where N = the desired number of equal divisions at the spindle.

Reduce this fraction to its simplest form. Use any whole number to represent complete turns, and use the denominator to determine the index plate to use. The last time I checked (just now) index plates with these hole circles were commonly supplied: 24, 25, 28, 30, 34, 37, 38, 39, 41, 42, 43, 46, 47, 49, 51, 53, 54, 57, 58, 59, 62, and 66. These hole circles usually come on a set of two or three plates. Of course, with a dividing head you can make your own index plates. If you make a homegrown dividing head with a worm wheel tooth count differing from 40 you will need to determine your own hole circle requirements. But for the following examples let's assume we have adopted the defacto standard of 40:1.

First a very simple example: we want to mill four flats on the side of a shaft to make a square end to match the square hole in a garden hose fawcett handle we found which we would like to use as a declination clamp on an equatorial mount. So we must divide the circle of the shaft into 4 parts:

40/4 = 10/1 = 10 full turns of the crank per division.

It doesn't matter which hole circle we use on the index plate since we have only complete revolutions of the crank to make for each advance of the spindle.

Too easy? Okay, say we want to divide a circle into 360 equal parts for a setting circle:

40/360 = 4/36 = 1/9.

Take the denominator 9 and determine which of your hole circles it will evenly divide. A quick glance at our list shows we have a 54 hole circle, which 9 goes into 6 times (9x6 = 54). Therefore, 6 holes in our 54 hole circle equals one ninth of a crank turn, which equals one 360th of a circle at the spindle (9x40 = 360).

How about another one? We need to make a bolt hole pattern in an adapter that we want to fit to a surplus space shuttle fuel line flange we scrounged from a high-tech scrap metal yard, which we intend to use as the base of an alt-azimuth refractor mount. Unfortunely this flange has a 13 hole bolt pattern; but fortunately we have a dividing head mounted on our drill press or milling machine table:

40/13 = 3 and 1/13.

Or in other words, 3 turns of the crank plus 1/13th of a turn per division. So to proceed, we set the plunger over our 39 hole circle (3x13 = 39), advance the crank a turn or so to take up any play in the divider, clamp the spindle, drill the first hole, unclamp the spindle, turn the crank 3 full turns plus 3 holes in our 39 hole circle, clamp the spindle, drill the second hole, unclamp, crank 3 turns plus 3 holes, clamp, drill, unclamp, 3 turns plus 3 holes, clamp, drill, unclamp, crank, clamp, drill, unclamp, crank, drill, unclamp, crank...

Easy. Here's a tougher one: divide that circle into 67 equal parts.

Give up? As handy as a dividing head is, there are a few times that you just can't get there from here without a detour or two along the way. For toughies like this there are additional techniques, like compound and differential indexing, involving moving the crank a number of holes in one direction using one hole circle, then turning the crank a number of holes in the other direction using another hole circle, or even rotating the index plate a certain amount. But that is beyond the scope of this discussion. There are also wide range dividing heads that incorporate an additional 100 tooth worm wheel between the crank and spindle. With one of these, divisions between 2 and about 400,000 are possible.

The Rotary Table

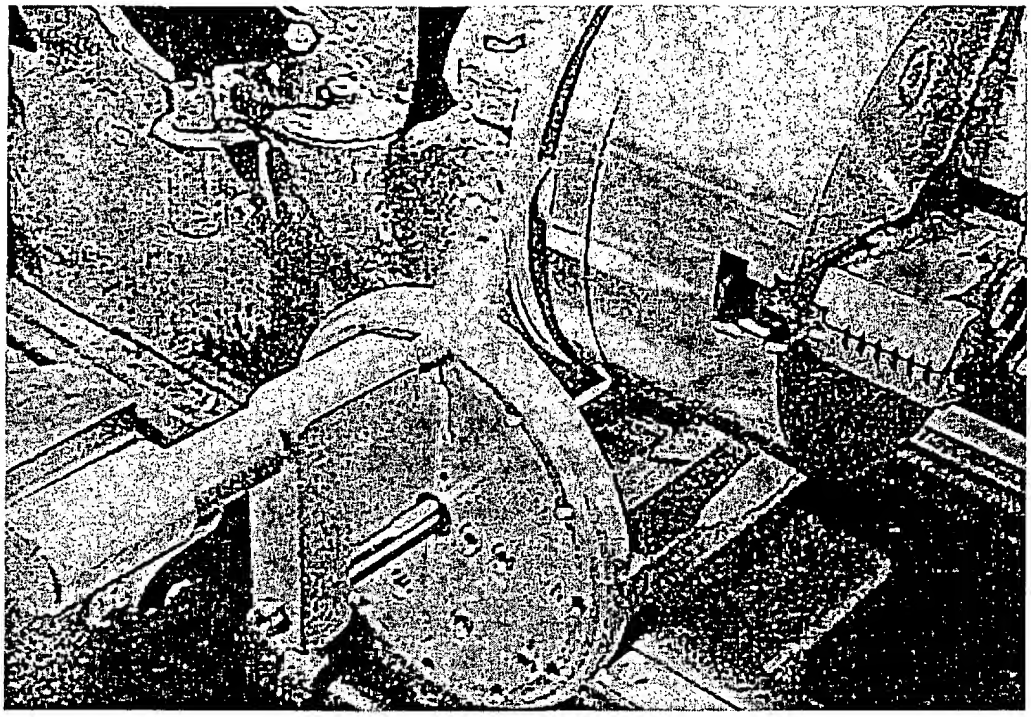
is another tool for dividing circles and for some applications is more versatile than the dividing head. It is constructed in a manner similar to the dividing head, with a precision worm and wheel, but is flatter in form and has a large slotted table (for hold-down clamps) instead of a chuck or collet attachment, and a graduated dial on the crank instead of a circle plate, where degrees and minutes of arc can be read directly or by vernier. Instead of thinking *divisions*, now we can think in ***degrees*** which is more straight forward for many of the applications that come to hand. The rotational axis is fitted with a brake to clamp its position while machining operations are conducted. Many commercially produced rotary tables can be tipped on their side for 90 degree operations, and some of the very expensive models are provided with the means to set them at any angle of tilt. Nice.

When it comes down to it, either device will do most of what the other will do.

Making Your Own

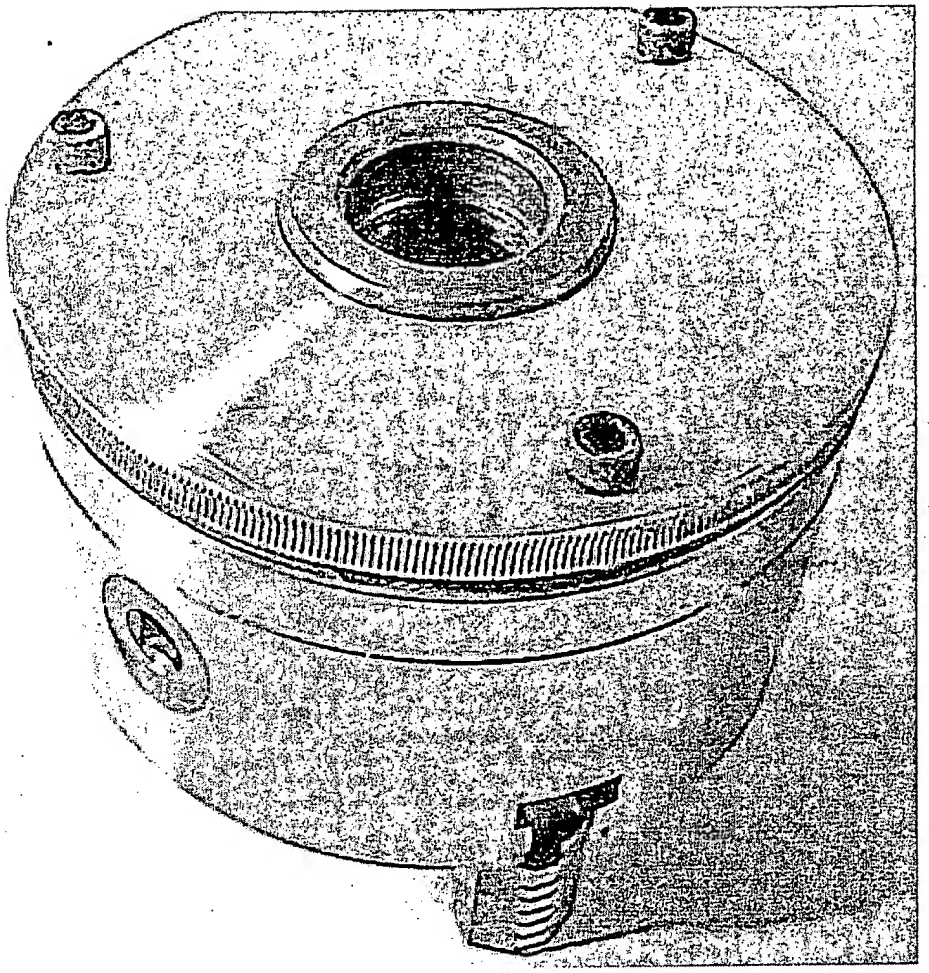
If (or when) you decide to make your own dividing apparatus, a setup similar to the wormgear-making fixture described in my article on cutting wormgears will be a good starting point. Make a nice worm gear set and mount it to the fixture. You can then use a little ingenuity to mount the worm with a crank and hole circle plate, a clamp for rigidity, and a means to mount a workpiece on top. This will provide the basic functionality for use with a drill press.

The setup I currently use for making setting circles, gashing gear blanks, and other jobs of that nature is similar to the setup described by Allan Mackintosh in *Advanced Telescope Making Techniques, Vol. 2.*

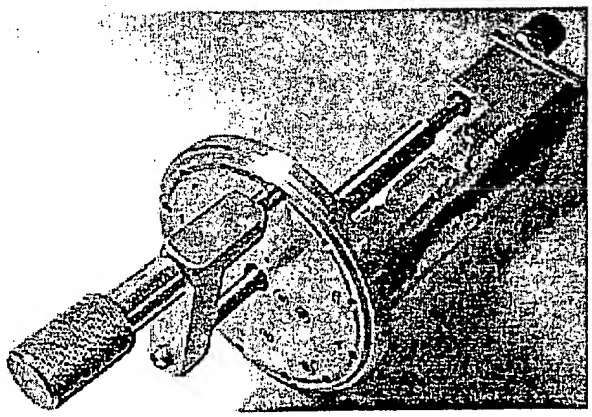


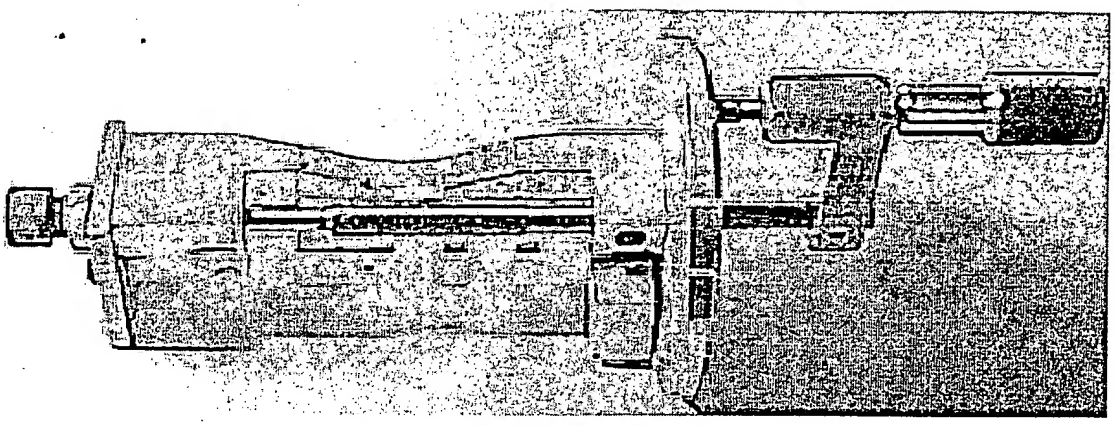
First of all, I made a 360 tooth worm gear set using the technique described in my wormgear making article with the blank bored to match the back of one of my lathe chucks and holes drilled to match the handy bolt pattern already present on the back of the chuck.

Instead of only 40 turns of the crank per revolution of the spindle as with a standard dividing head, this setup requires 360 turns, providing 9 times the resolution (**crank turns = 360/N**) and also allows quick mental changes between the two concepts of *divisions* and *degrees*.



The worm is mounted in bearings contained in a wide U-shaped assembly of aluminum which was made to slide along the lathe ways under the chuck and rotate into position, meshing the worm to the wheel where it is retained in place by a thumbscrew against the back of the far lathe way. The front of the gadget is held firmly against the front of the ways by the back of an index plate which provides the hole circle for a crank's spring-loaded index pin to engage. A small block of aluminum is then fixed to the back of the index plate (with a thumbscrew) which keeps the worm assembly from rotating away and disengaging from the worm. Quick installation, no tools required.





As of yet, I have needed only one 12-hole circle which provides a resolution of 4320 divisions (or 1/12 degree, or five minutes of arc). Half of that, or a resolution of 2.5 minutes of arc, is easily guesstimated by positioning the index pin midway between the index holes. Any item held in the lathe's chuck can now be scribed or gashed simply by mounting the tool on the lathe's toolpost.

For gashing I use a Dremel tool with a small slitting saw. The Dremel is held vertical by an L-shaped bracket held in the lathe's tool post.

This was quick, easy, accurate, and versatile. Worth it's weight in gold. (Well, silver anyway!)

- JS